THE

Indian Tea Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART II.

1928.

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS,
3 & 4, Portuguese Church Street.

1928.

THE

Indian Arts Association.

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL.

PART IX.

1878-79.

CALCUTTA:
PRINTED AT THE CATHOLIC ORPHAN PRESS.

CONTENTS

	Page.
The use of Artificial Manures	63
Notes on the Growth of Young Tea Plants and its Relation to Red Spider Attack	80
Moisture Changes during the Manufacture of Black Tea	90
Cold Weather Spraying	99

THE USE OF ARTIFICIAL MANURES.

BY

H. R. COOPER.

The use of artificial manures in tea cultivation is now very general, but in many quarters a great deal of prejudice against them is still met. On some gardens, for example, no manures other than those of organic origin, like cattle manure, oilcake and animal meal, are allowed to be used. Even in some places where "chemical" measures are being used with obvious advantage, the opinion is sometimes expressed that the good cannot last. The idea appears to be that there is something unnatural about a concentrated soluble manure. The great effect produced by the small quantity suggests that the manure acts like a tonic rather than a food; it is felt that there must occur eventually an unfavourable reaction, when the plants will suffer from the effects of their unnatural feeding.

Plants, however, can only take the nitrogen, potash and phosphoric acid which is necessary to them, from a complicated mixture, like, for example, cattle manure, when this has broken down in the soil into simple soluble substances, such as occur ready formed in soluble artificials.

The deterioration of a soil, when cropped without manures is due almost entirely to depletion in these three substances, and it has been shown by long-continued field experiment in many places that a crop's requirement of these essential foods can be as well supplied by soluble artificials as by cattle manure.

In the January number of the Journal of the Ministry of Agriculture, H. V. Garner of Rothamsted Experimental Station,

collects together the results of experiments on this question. His conclusion is—

"There is no doubt that the successful use of fertilizers without dung requires a knowledge of their properties and their relations to soils and crops, but that they can maintain fertility for a considerable time, and compare not unfavourably with repeated dressings of dung has been shown in a number of trials. In most of the recorded cases yearly applications of farmyard manure have been compared with annual doses of a complete mixture of fertilizers, the dung providing more total plant food than the artificial but, probably, rather less plant nutrients in a readily available form.

"The general trend of the results is in the same direction; and there is no doubt that under the conditions of the experiments artificials used alone have maintained the cropping power of the various soils at a level not much inferior to that produced by annual application of farmyard manure. Apart from a somewhat more kindly physical condition shown by land receiving farmyard manure, the main difference between the dunged land and that receiving artificials lies in the extent of the residual effect which, as we know from certain Rothamsted experiments, is much greater with dung than with artificial fertilizers."

Rothamsted (heavy soil), Continuous Cropping.

Average yields per acre.

Manures to each crop.	Wheat.	Barley.	Mangolds.
	71 seasons.	70 seasons.	45 seasons.
No Manure	12 bu.	15 bu.	3½ tons
14 tons dung (approx. 186 lbs. N.)	34 „	46 „	18 „
Complete artificials :—			
(43 lb. N.)	22 „	41 „	...
(86 lb. N.)	31 „	...	18 „

Woburn (light soil), Continuous Cropping Since 1876.
Average Yields per acre, 1915-24.

Manures to each crop.	Wheat.	Barley.
No manure	8·0 bu.	9·6 bu.
7 tons dung (approx. 82 lb. N.)	20·6 ,,	27·7 ,,
Complete artificials (20 lbs. N.)	16·4 ,,	18·7 ,,

Saxmundham (heavy soil), Rotation Cropping.
Average Yields per acre, 1910-23.

Manures to each crop.	Wheat.	Mangolds	Barley.	Peas and Beans.	Cloverhay.
	13 crops.	13 crops.	12 crops.	10 crops	3 crops.
No manure	18 bu.	5 tons.	17 bu.	20 bu.	32 cwt.
6 tons dung (72 lb. N.) ...	29 ,,	18 ,,	30 ,,	39 ,,	80 ,,
Complete artificials (30 lb. N.)	30 ,,	17 ,,	31 ,,	36 ,,	60 ,,

Bramford (light soil), Rotation Cropping.
Average Yields per acre, 1902-7.

Manure to each crop.	Wheat.	Mangolds.	Barley.	Peas.	Clover-hay.
	6 crops.	6 crops.	6 crops.	3 crops.	2 crops.
No manure	19 bu.	12 tons.	27 bu.	31 bu.	37 cwt.
6 tons dung (72 lb. N.)...	21½ ,,	16 ,,	38 ,,	29 ,,	33 ,,
Complete artificials (30 lbs. N.)	25 ,,	18 ,,	39 ,,	24 ,,	29 ,,

The figures obtained in the Rothamsted experiments are of the greatest interest because so long continued.

Here the soluble artificial manures, sulphate of amonia, sulphate of potash, and superphosphate have for seventy-one years

maintained yields nearly equal to those obtained by the use of farmyard manure supplying more than twice as much plant food. This would suggest that the farmyard manure is less efficient than the soluble artificial manure, and as a direct source of the most important plant foods, no doubt it is.

Annual application of a complete mixture of soluble artificials supplying 129 lbs. nitrogen, 80 lbs. phosphoric acid and 100 lbs. potash has at Rothamsted over 50 years, maintained an average yield of 36.9 bushels of wheat against 35.6 bushels from 14 tons farmyard manure estimated to contain 186 lbs. nitrogen, 78 lbs. phosphoric acid and 235 lbs. potash.

On the straw the difference is still more marked being 40.9 cwt. from artificials as against 33.9 from the farmyard manure.

The distrust of artificial fertilizers shown by British farmers when they were first introduced was very natural. The prejudice against them may now be said to have disappeared, although as Garner writes—"The accepted view is that artificials should be "used as a supplement to, but not as a substitute for, farmyard manure." It is time that the prejudice against soluble artificials which still exists among some of those interested in tea should disappear.

When, as at Rothamsted, sulphate of ammonia has been used for 71 consecutive seasons with the result quoted, it can no longer be argued that the results shown at first must be followed by disaster. That some knowledge is necessary in the use of artificials is exemplified by the facts that on soils poor in lime, the continuous use of sulphate of ammonia has rendered the soil eventually too acid to grow certain crops, and that at Rothamsted crops began to fall off when sulphate of ammonia was used without potash or without phosphates.

On such points sufficient knowledge is available to the tea industry, although many minor questions affecting manuring still require investigation.

In the case of tea we may take it as certain that if any soil is completely unmanured, the crop produced will fall to a very low level. If manuring is confined to the use of as little cattle manure as is commonly available, crop will not be maintained at a much higher level.

Proper combinations of artificials can be used to supply sufficient of the three absolutely essential plant foods (nitrogen, phospheric acid and potash) to maintain high crops at a relatively low cost, even if no form of organic matter be applied.

If manuring were at any time stopped yields from the artificially manured soil would drop very rapidly back to those obtained from unmanured soil, while the crops on the soil manured with farmyard manure would decrease only slowly. It is estimated that, if manuring ceased, it would be 50 years before the crops from the farmyard manure plots at Rothamsted became equal with those from unmanured soil.

This residual effect however has been obtained at a very wasteful expenditure of nitrogen.

Russel publishes the following balance sheet :—

Nitrogen in soil in 1865 ...	·175%	...	4,340	lbs.	per acre
Nitrogen added as manure, rain (5 lbs. per annum) and seed (2 lbs. per annum)			9,730	,,	,, ,,
Nitrogen expected in 1912		...	14,070	,,	,, ,,
Nitrogen found in 1912 ...	·245%	...	5,730	,,	,, ,,
Loss of nitrogen from soil in 47 years			8,340	,,	,, ,,
Nitrogen accounted for in crops		...	2,550	,,	,, ,,
Balance being dead loss ...		...	5,790	,,	,, ,,
Annual dead loss ...		...	123	,,	,, ,,

The loss comes mainly from washing out of the soil nitrates formed from the cattle manure; but when such large doses of

dung are used there is some loss also from production of gaseous nitrogen due to "denitrifying bacteria." Such losses are unavoidable in "high farming." The richer a soil the more rapidly does it lose nitrogen.

There are two sources of natural gain of nitrogen in the soil, *viz.* :—bacteria associated with leguminous weeds, and certain free living bacteria, both of which fix nitrogen from the atmosphere. If never manured a soil would lose nitrogen till a point is reached when the rate of loss is counterbalanced by the rate of gain from these sources.

The unmanured plot at Rothamsted has reached this point.

Nitrogen in soil in 1865 .105 p. c. ...	2,720 lbs.	per acre.
Nitrogen added in rain and seed ...	330 ,,	,, ,,
Nitrogen expected in 1912 ...	3,050 ,,	,, ,,
Nitrogen found in 1912 .103 p. c. ...	2,510 ,,	,, ,,
Loss from soil	540 ,,	,, ,,
Nitrogen accounted for in crop ...	750 ,,	,, ,,
Balance being gain of nitrogen ...	210 ,,	,, ,,
Annual gain	5 ,,	,, ,,

This plot may be expected to go on giving about 13 bushels wheat per acre without manuring; but manuring will show a profit whenever the value of the increased crop exceeds the expenditure on manuring.

The use of small annual dressings of artificials maintains a much higher state of fertility without very wasteful expenditure of plant food.

An artificial mixture providing 43 lbs. nitrogen (2 cwt. sulphate of ammonia) at Rothamsted has maintained for the last 71 years a crop of 22 bushels wheat against 12 for the unmanured plots.

Of this plot Hall wrote in 1905,—

"On Plot 6 only 43 lbs. of nitrogen are supplied, little more than the amount removed by the crop. If we consider the other

sources of loss of nitrogen to the soil, such as the removal of weeds, drainage, etc., it becomes clear that the 43 lbs. of nitrogen in the manure are not sufficient to repair the annual withdrawals of nitrogen. Consequently we should expect some diminution of fertility on this plot, and analyses of the soil seem to show that it is slowly losing nitrogen. "

" The curve expressing the crop on plot 6. . . . indicates a considerable fall in fertility during the first ten years and a comparatively constant position for the last 40 years. Thus this plot seems to have reached a position of comparative stability when the annual withdrawal of nitrogen is almost balanced by the additions from all sources, so that the fertility of the land is declining very slowly if at all. "

On this plot therefore good crops are being maintained without any waste of manure.

Larger dressings of artificials can maintain a still higher level of fertility but only with a considerable waste of manure.

Tea which has never been manured for 40 years must have come very close to the point of balance, and if it continues unmanured may be expected to maintain its present yield unless so weakened that disease attacks it; but the yield is much less than the virgin soil yielded, and much less than could be obtained with moderate manuring.

Manures are now very cheap, while tea is still a very valuable crop. Manuring must pay.

Experiments show that it does, very handsomely. The following experiment at Borbhetta on three pairs of adjoining plots is an example.

The " M " plots received 150 lbs. sulphate of ammonia, 150 lbs. superphosphate, and 60 lbs. muriate of potash. The " U " plots received the potash and phosphate only which have been shown on other plots to make very little difference for the better when used alone. Tea's main requirement is nitrogen.

Yields in mds. tea per acre.

Comparison of manured with unmanured tea.

	1920.		1921.		1922.		1923.		1924.		1925.		1926.		1927.		Total gain for 7 yrs. manuring 1922-1927.	Average annual gain mds. tea per acre.
	M*.	U*.	U.	U.	M.	U.	M.	U.	M.	U.	M.	U.	M.	U.	M.	U.		
1	9·7	9·2	7·5	7·6	8·4	8·4	10·1	9·4	9·5	9·9	10·1	7·6	9·5	7·3	8·7	5·3	...	...
2	8·1	8·1	6·4	6·9	7·6	7·5	9·4	8·1	9·4	7·2	11·4	7·6	9·7	6·7	8·9	5·8	...	...
3	8·9	9·4	6·7	7·5	8·3	8·0	9·2	8·4	8·7	7·2	9·4	7·3	8·7	6·5	8·9	6·2	...	...
Average ...	8·9	8·9	6·9	7·3	8·1	8·0	9·6	8·6	9·2	7·4	10·3	7·5	9·3	6·8	8·8	5·8	...	...
Difference due to manure ...	...	...	...	...	0·1	...	1·0	...	1·8	...	2·8	...	2·5	...	3·0	...	11·2	1·6

*M = Manured.

*U = Unmanured.

Cropping previous to 1920 had indicated that the "M" plots were initially poorer than the "U" plots. In 1920 the manure applied made the plots equal in crop. In 1921 no manure was applied and the plots which had been manured dropped back. The tea was unpruned in 1920, but was top pruned in all succeeding years, hence the drops in 1921 as compared to 1920.

The 1922 manuring again made the plots equal in crop. In succeeding years increasing gains are recorded from manuring, due mainly to increasing deterioration of the unmanured plots.

The tea was planted in 1916 on old grazing land which was poor, but for a few inches under the thin turf had accumulated some reserve of nitrogen which by now must be nearly cropped out, so that little further soil deterioration is expected; but all plots on this poor soil are diseased, and the manured tea will probably resist disease the better.

At the end of 1925 the unmanured plots looked so poor that plucking was made lighter on all plots, in order to keep the check plots going. Otherwise yields from manured plots probably could have been maintained nearer the 1925 level; but the 30 lbs. nitrogen applied annually is not sufficient to save the soil from deterioration. 1927 was a bad year climatically while 1926 was exceptionally good : hence the big differences in yields for those two years.

The tea was very finely plucked and would have averaged at least 14 annas per lb. or Rs. 70 per md. in Calcutta. Increased costs for plucking, manufacturing, boxes, and freight probably would cost less than Rs. 20 per md. : so that the increased crop while on the bushes can be reckoned at, at least, Rs. 50 per md. The 1.6 mds. annual increase is therefore worth Rs. 80 at least.

Against this the manuring costs :—	Rs.	As.
150 lbs. sulphate of ammonia at Rs. 170 per ton ...	11	6
150 lbs. superphosphate at Rs. 75 ,, ...	5	0
60 lbs. muriate of potash at Rs. 135 ,, ...	3	10
Freight and carting on 360 lbs.	5	10
Application	2	0
Total Rs.	27	10

Up to the present, then, the annual profit from manuring has been at least Rs. 52 per acre. For the future, profit will be greater because the average difference between manured and unmanured plots is likely to remain nearer to 3 maunds than 2 maunds.

If manuring were now stopped yields from the plots previously manured would fall back until they equalled those from the plots never manured.

At Rothamsted from plots manured with sulphate of ammonia in alternate years only, about 30 bushels are obtained in the manured years, and only 15 in the unmanured years. There is obviously very little residual effect from the manure since the plots never manured average about 13 bushels.

On tea, which occupies the soil for many years, differences would not be so marked; because although the residual effect in the soil is little, the improved bush left does not so rapidly fall off in yield, probably on account of an extended root range. In addition the prunings and leaf fall added annually help a lot in the maintenance of soil fertility. The cellulose so added feeds the bacteria which fix nitrogen from the air and thus add to the soil nitrogen supply. The addition of prunings also is followed by a disappearance of nitrate from the soil, which is accounted for as being used by the cellulose destroying organisms to build up their own bodies which afterwards die. The addition of soluble nitrogen after pruning therefore provides some organic nitrogen (as dead micro-organisms) part of which remains in the soil.

However it appears quite clear that soluble manures must be added annually, otherwise their cumulative effect is lost.

If manured only occasionally tea is likely to give significantly improved crops only in the manured years, and to fall very near to the plots never manured in those years when manures are not applied. We believe that the quite common distrust of " chemical manures " in tea cultivation, is due to the very common practice of giving big doses occasionally, when the subsequent falling off becomes so noticeable. There are many indications that such a practice, which entails that the bush grows alternately in very rich and very poor soil, upsets the whole food-supply system of the bush and increases liability to disease.

On the other hand we have every reason to believe that regular application of small quantities of properly balanced " chemical " manures, will maintain high *average* yields at a very cheap rate, and that larger quantities will produce increasing yields, even if no organic matter other than that provided by the bush itself is ever applied. Such a practice however is not advised.

Apart from the food it supplies organic matter improves the physical condition of the soil, a point of great importance to the health of the bush.

The advantages of a full supply of organic matter were fully dealt with by the Bacteriologist in this Journal 1927, Part III, page 115, and need not be repeated here.

These advantages are shown in practice on experimental plots in many places.

The wheat plots at Rothamsted to which no organic matter has been applied for 71 years, are very little affected in average crop, although the soil is gradually losing organic matter. Close examination of the figures, however, shows that the dunged plot maintains its yield well in dry years, while the crops from artificials fall much below their average. Tea has, annually, to pass

through a period of drought, and when such droughty periods are longer than usual, tea always suffers badly and its resistance to disease is seriously weakened. Much of the trouble from disease in droughty districts is, undoubtedly, due to this cause. The evil effects of drought can be greatly diminished by maintaining a soil's organic matter at a high level. It has been pointed out by C. M. Hutchinson that the alternative to manuring in India has too often been increasing cultivation which by stirring the soil increases the rate of formation of nitrates from the soil's organic matter and hence increases the rate of loss of this material which is so difficult to replace. Artificials can therefore be used to decrease the rate of loss of organic matter. The enormous majority of tea soils however would be much improved by a considerable increase.

Nitrogen, phosphoric acid, and potash also are not quite the only foods essential to a plant, and there is evidence that soils supplied with these only become gradually depleted of substances necessary to plants in minute quantities only and crops consequently decrease slowly. There is some evidence too, that cattle manure may contain, in very small quantity, substances analogous to the vitamines which are of such importance in human food.

Cattle manure is in every sense a complete food. It is advised therefore that as much cattle manure as can be obtained at reasonable rate should be applied. It should not however be applied in wasteful doses.

Analysis of the old, washed cattle manure used at Borbhetta is made annually. When "dry" (containing 50 per cent. moisture), that is, in its normal state as bought from villages in dry weather, it contains about—

.5 per cent. nitrogen
.6 per cent. phosphoric acid
.5 per cent. potash.

Since it may often be wetter than this we can take it roughly, that, 1 ton cattle manure supplies—

10 lbs. nitrogen
12 lbs. phosphoric acid
10 lbs. potash.

A dose of 20 tons provides 200 lbs. nitrogen. A crop of 10 mds. tea per acre uses 40 lbs. nitrogen. Of the remaining 160 lbs. the greater part is washed out in the first year, and the remainder stays in the soil to be partly washed out and partly used by crops in succeeding years.

If only 5 tons per acre is used, the wastage is very considerably less. If this quantity does not provide sufficient available nitrogen for the purpose in hand, the balance is better made up by a small additional dose of artificial.

5 tons cattle manure would provide 50 lbs. nitrogen, 60 lbs. phosphoric acid, and 50 lbs. potash. Its effect in the first year would be much less than that of the same quantities of food as soluble artificials, because so much less of it is available as plant food.

Used in small quantities however the food in cattle manure may be considered eventually to be nearly as valuable as that supplied as artificials.

One ton cattle manure may then be considered to supply plant food worth—

	Rs.	As.
Nitrogen 0.5 per cent. at Rs. 8.5 per unit ...	4	4
Phosphoric acid 0.6 per cent. at Rs. 2.5 per unit ...	1	8
Potash 0.5 per cent. at Rs. 2.7 per unit ...	1	6
Total value per ton ...	7	2

It is usually obtainable at a much smaller cost even including the high cost of application; so that we may consider that the organic matter is obtained for nothing. At that price it is so

well worth having, that one can only advise the application of as much as is obtainable.

There is one objection to its use : it contains the seeds of weeds. On the few areas where good tea has grown so thickly and widely that no jungle grows under its shade, it would be unwise to use cattle manure which would necessitate cultivation. Such tea, however, would seldom need cattle manure. Loss of organic matter from a soil so fully occupied by bushes must be very slow, and is probably more than counterbalanced by the annual gain from leaf-fall and prunings.

Very little cattle manure is commonly available. The growth of shade-trees and of green crops is therefore advised up to the capacity of the available labour to deal with them without neglecting the suppression of weeds among the tea.

As with cattle manure, so with green crops. The quantity which can be applied to the soil is normally much below that which is necessary to maintain fertility. Nor would it be advisable to depend upon green crops as the main source of nitrogen in any case.

Green crops retard the growth of tea among which they are growing and there is a further set back to growth after they are hoed in. Gains from green cropping must therefore be slow.

The nitrogen supplied to the soil also does not show up in improved growth of the bush till at least 6 weeks after burial. Since growth of green crops will not start till rain falls, usually about the middle of March, burial of green crops cannot start till about the end of April; and since hoeing in must be spread over at least six weeks, it will not finish before the middle of June. This means that bushes receive no benefit till between the middle of June and the end of July.

There are definite experiments establishing the fact that application even of immediately available manures is enormously more valuable in April than in June; while the general indications are that available plant food is best supplied soon after

growth starts which means application of manure some time between mid-February and mid-April, depending upon manure, soil, and season.

As sources of nitrogen, therefore, it is absolutely necessary to depend mainly upon artificial manures.

It is not within the scope of this article to deal with the question of choice among the many artificials available; but it may be pointed out that it is not generally economically sound to use concentrated manures as sources of organic matter.

The commonest organic manures in use are oilcake and animal meal.

In the case of oilcake 8 mds. is a normal " maintenance " dressing per acre.

This would supply about—

29 lbs. nitrogen
12 lbs. phosphoric acid
6 lbs. potash.

and on the present market would cost about Rs. 24.

Using sulphate of ammonia, superphosphate, and sulphate of potash, plant food equal to 8 mds. oilcake would cost Rs. 13-8; so that when buying oilcake we may take it that roughly we pay Rs. 10-8 for about 8 mds. of organic matter. How much more could be obtained for the price in the forms of cattle manure and green crops!

Five mds. Acme animal meal would provide 28 lbs. nitrogen, 28 lbs. phosphoric acid, and 20 lbs. potash at a cost of Rs. 31-4.

Using the plant foods in soluble form the equivalent of 5 mds. animal meal would cost only Rs. 15-6.

There are cases where, even at high prices, organic manures are advisable, but as a general policy for average soils it is advised that dressings of cheap soluble manures should be applied

annually. These should be supplemented as far as is possible by cattle manuring and green cropping.

These bulky organic manures will serve as sources of organic matter to maintain the physical condition of the soil, and assist to maintain crops in bad seasons. They will also add a certain amount of slowly soluble nitrogen to build up a reserve against bad times when manuring might have to be stopped.

In connection with manuring the question of quality has always to be considered. A larger crop at a correspondingly reduced price would show no profit.

Of late years there has been a tendency to blame manuring whenever quality has fallen below what was hoped for. In particular the amount of stalk is very often stated to have increased since manuring became more general.

Since much harder rolling has become general in order to obtain stronger liquors, it would be more reasonable to connect hard rolling with any general increase in stalk which there may be. Hard rolling would be expected to strip off the black skin and expose red fibre; whereas stimulus to growth by manuring would be expected to decrease the proportion of hard banjhie and to yield more succulent shoots generally.

The composition of the leaf however can be changed by manuring. This change on very poor tea may often be for the better, but any over-rapid growth undoubtedly tends towards a change in quality for the worse. Manures therefore must not be used to increase the rate of growth from the existing number of shoots; but to enable a larger bush to remain healthy and sufficiently fed to maintain a larger number of yielding shoots.

Rushes of quickly grown leaf must be avoided.

Any tendency to decrease in quality from manuring can be made up for by plucking and to a certain extent by pruning, because these factors make more difference to leaf composition than manuring does. In the good yielding year 1926, the average

crop in the Brahmaputra Valley was 8 mds. per acre; yet many gardens produced 10 and 12 mds. per acre at prices well above the average. High yield is therefore not necessarily associated with poor quality.

In practice, the tendency is rather the other way. Gardens which manure heavily are usually found near the top of the market for prices. This is only natural. A garden which can make a good crop with good plucking can afford to pluck good leaf. On a deteriorating soil the temptation to keep up crop must tend towards coarser plucking. Generally speaking the poor teas come from such soils : although they come also from very rich soils (such as bheel soils) where growth is very rapid.

Moderate regular doses of properly balanced manures should maintain good bushes which will produce good crops of good tea. Such good bushes can be plucked more closely, can be less heavily cleaned out, and need be heavy pruned less often. These factors count for a great deal in the production of good teas.

NOTES ON THE GROWTH OF YOUNG TEA PLANTS AND ITS RELATION TO RED SPIDER ATTACK.

BY

E. A. ANDREWS.

In the early part of 1927 a small nursery was established at Tocklai to provide plants with a known history for work in connection with susceptibility to disease. Careful observations of the development of these plants have been recorded, and although this was mainly done for subsequent reference when studying the behaviour of the plants, the observations afford certain information on the behaviour of tea in its early stages. Very little has been published on this subject, and it may be therefore not without interest to put on record the results of the observations.

The seed used was of light-leaved Assam "jat." 100 seeds, on being tested in the usual manner, gave the following results :—

	Sinkers.	Floaters.	Total.
Healthy seeds ...	95	1	96
Seeds punctured by the tea-seed bug, but not infested with fungus ...	2	—	2
Seeds infested by pathogenic fungi ...	2	—	2

Taking 2 "starred" seeds as equivalent to 1 good seed, and discarding infected seed as bad, the seed was therefore 97 per cent. good.

The average weight of each seed was 1.98 grams, which gives 18,327 seeds to the maund of 80 lbs.

Germination.—396 seeds were set to germinate in damp sand on January 25th. These were taken up for planting on February 24th (30 days later).

By that date 305, or 77 per cent. of the seeds, had germinated, the remainder being ungerminated. Of the germinated seeds,

88, or 22 per cent. of the whole, had made root-growth of 1 inch or more.

89, or 22 per cent. of the whole, had made root-growth of ½ inch or more, but less than 1 inch.

46, or 12 per cent. of the whole, had made root-growth not attaining ½ inch.

82, or 21 per cent. of the whole, had cracked only.

Plants obtained.—It is interesting, in view of the above figures, to take stock of the plants obtained. Observations were made towards the end of April, as marking the growth at the beginning of the rainy season (and to include the "chota barsat"), and again in the middle of October, as marking the end of the rainy season. 256 germinated seeds had been planted in February, and 16 ungerminated seeds.

187 of the germinated seeds had thrown up plants by the end of April, *i.e.*, 73 per cent. of the germinated seeds planted. 6 of the ungerminated seeds had thrown up plants, *i.e.*, 37½ per cent., though the number is too small for this latter figure to be of much value.

By the middle of October, there were 164 plants still standing from the germinated seed, or 64 per cent., while 6, or 37½ per cent., were still standing from the ungerminated seed. After the inspection in April, vacancies were filled in with 49 germinated and 30 originally ungerminated seed, of which 44 gave plants. Some of the latter seed had germinated in the meantime, and unfortunately the record was not kept of which was which. In the end, however, 214 plants were obtained from 351 seeds, of which 305 had germinated, and 46 had not germinated, at the original time of planting.

The figures for this result are :—

Seed germinated at original time of planting ... 87 per cent.
Plants obtained at end of first rains ... 61 ,,

that is to say, the number of plants obtained at the end of the first rains was 70 per cent. of the number of seeds which germinated in 30 days.

Of the 214 plants,

93 were good plants (10 inches and upward in height)
77 ,, fair ,, (6 to 10 inches)
77 ,, poor ,, (less than 6 inches)

i.e.,—26½ per cent. of the whole were good plants
22 ,, ,, ,, fair ,,
12½ ,, ,, ,, poor ,,

i.e.,—from 1 maund of seed would have been obtained 5,057 good plants—just enough to plant 2 acres 4 ft. 6 in. triangular, and 4,032 fair plants—enough to plant 1 3/5 acre.

The Soil Factor.—The soil in which the seeds were planted was by no means ideal for a nursery. It had been under tea before, and, since uprooting the tea, had been divided into 1 null plots, all of which had received different treatments at one time or another. This arrangement of plots was maintained when planting the nursery, and the growth made by the plants in different plots was exceedingly varied. An attempt to compare the growth obtained in the various plots was made as follows. Each good plant (10 inches or more in height) was weighed with the number 3, each fair plant (6 to 10 inches) with the number 2, and each poor plant (less than 6 inches) with the number 1.

In a plot in which every plant was a good one the growth was taken as 100 per cent., and the percentages for the plots calculated on this. The following are the figures obtained :—

2B	66.7
2C	72.9
3B	79.2
3C	27.1
4B	87.5
4C	89.6
5B	77.1
5C	56.2
6B	77.1
6C	56.2
7B	54.2

7C	35·4
8B	50.0
8C	56.2
9B	20.8
9C	52.1
9D (ungerminated seed)	29.2

The great variation in growth in different plots is well shown in the table, being from 90 per cent. to 20 per cent.

Most of the area had received lime at various times in the past, and acidity tests made on adjacent plots throughout the season had shown the soil to be too little acid for tea to do really well. Samples of soil were therefore taken from three plots, the worst at one end of the series, the worst at the other end of the series, and the best plot, and tested by the Chemical Branch of the Department for acidity. The percentage growth and acidity figures are given below :—

Plot.	Percentage Growth.	Hopkins Acidity.	pH direct.	pH of nitrate of potash extract.
4C	89·6	196	5·7	4·4
3C	27·1	49	6·0	5·0
9B	20·8	35	6·0	5·2

and show distinctly that the degree of acidity of the soil in the different plots has had a great influence on the growth obtained, the soil in the best plot being much more acid than in the other two, while in the better of those two the soil is a little more acid than in the other.

This tendency towards neutrality in many of the plots has undoubtedly had an effect in reducing the amount of growth obtained, and also, probably, in actual reduction of the number of plants obtained, for in certain cases seeds which had germinated very strongly at the time of planting failed to give plants as will be seen from the account, given below, of the relations between the vitality of the seed at the time of planting, as measured by root-growth, and the vitality of the plants at the beginning and end of the rains, as measured by height.

The Effect of the Initial Vitality of the Seed.—As stated above, the seed did not germinate evenly, and at the time of planting the seed was classified into five distinct grades, according to the degree to which development had proceeded. It is interesting to compare the growth made by plants from each grade of seed at the beginning and end of the rainy season, and this is shown in the following table. In this table the plants obtained from each grade of seed towards the end of April and at the middle of October are graded according to the growth made, and the numbers expressed in percentages of the number of seed in each grade.

	Growth shown by seed when planted.				
	Rootlet 1″ or more.	Rootlet ½ to 1″.	Rootlet less than ½″.	Cracked.	Ungerminated.*
Development by April 22nd.	%	%	%	%	%
4″ and more in height	8·0	6·7	2·2	0·0	0·0
3″—4″ „ „	31 8	19·1	4·3	3·0	0·0
2″—3″ „ „	32·9	21·3	21·7	15·1	6·2
1″—2″ „ „	11·4	13·5	13·0	15·1	25·0
0″—1″ „ „	3·4	10·1	17·4	21·2	6·2
Appeared later	0·0	1·1	0·0	3·0	0·0
Dead	12·5	28·1	41·3	42·4	62·5
Development by middle of October.					
10″ and more in height	42·2	34·8	26·9	15·1	6·2
6″ to 10″ in height	27·3	16·8	13·0	21·2	18·7
Less than 6″ in height	8·0	11·2	10·9	12·1	12·5
Dead	21·6	37·1	50·0	51·5	62·5

* These percentages are hardly comparable, as the number of ungerminated seeds planted was much less than the number of germinated seeds. They do show, however, that some of the backward seeds gave better plants than some of the forward seeds, and are included in the table on this account.

The results in this table show clearly that the greatest percentage of good plants has been obtained from the seed which germinated most strongly and that the percentage decreases on passing down the grades of seed, while the percentage of deaths increases.

Thus vitality of the seed to begin with is an important factor in the results obtained, a factor which even the extreme variation in soil conditions does not mask. At the same time, it is clearly evident that slow germination does not necessarily mean that a poor plant will be obtained, for some of the ungerminated seed has given good plants by the end of the rains, although the figures for April show that they were then behind the others. Soil conditions would of course produce this result, but as the ungerminated seed was planted at the worst end of the series of plots, it would appear that the result may accrue independently of soil conditions. The percentage of good plants obtained from the backward seed, however, is so small that the cost of planting and upkeep would hardly be repaid, and it is obvious that rapid germination in a consignment of seed is a necessary preliminary to the growth of a good nursery.

Growth during the Cold Weather.—It is well known that nurseries often make a good deal of growth during the cold weather. The cold weather just past was one in which, owing to the extreme drought (at Tocklai only 7.41 inches of rain were recorded from the end of October to the end of April, against 19.76 the previous year), such growth might be expected to be at a minimum. Measurements of the height of the plants were made in the middle of April 1928, and we are thus able to record the growth made—1, from the time of planting to the end of the first rains, 2, during the rainy period of 1927, 3, during the cold weather 1927-28.

1. By the middle of October last the plants had attained an average height of 9.11 inches, with a maximum of 27.

2. During the rainy season (mid-April 1927 to mid-October 1927) the growth made was—average, 7.17 inches; maximum, 24½.

3. During the cold weather (mid-October 1927 to mid-April 1928) the growth made was—average, 5.73 inches; maximum, 15.

The plants were not watered, and indeed received no attention beyond forking in of the jungle. In the following table the growth made at the end of the cold weather is compared with that made at the end of the preceding rains.

Development by mid April 1928.	Development by mid-October 1927.		
	Good 10 ins. and more.	Fair 6—10 inches.	Poor Less than 6 ins.
Very good, 24 inches and more ...	18·1%	.....	.....
Good, 18—24 inches	42·5%	15·6%	.....
Fair, 12—18 inches	39·4%	45·4%	4·4%
Poor, 6—12 inches	.....	35·1%	31·1%
Very poor, less than 6 inches ...	.....	1·3%	31·1%
Dead	.....	2·6%	33 3%

It will be noted that the plants which had shown the greater vitality right through give the largest proportion of good bushes, but that in each grade there is a percentage of plants which has overtaken some of the plants in the higher grades. It has to be observed, again, that such plants occur in the poor plots as well as in the better ones, so that here, again, the overtaking would appear to occur independently of soil conditions.

Vitality of Plant and Liability to Red Spider Attack.—Red Spider appeared on the plants towards the end of January, and continued well into February. In the middle of February the reaction of the plants to red spider attack was noted, and consideration of the observations made is not without interest.

The various plots, as shown above, differed considerably in the growth made by the plants. They were also found to differ considerably in their reaction to red spider, and the following table gives the percentage intensity of infection in each plot :—

Plot.	*Percentage Intensity of Infection.*
2B	35·3
2C	15·3
3B	18.7
3C	7.1
4B	16.7
4C	16.7
5B	35·5
5C	36.1
6B	23·3
6C	25.0
7B	12.5
7C	17.0
8B	25.0
8C	12.5
9B	3·3
9C	15.1
9D	12.5

Comparison with the growth table given above shows that, while the behaviour of the plants, on the whole, is irregular, the three plots with least growth (3C, 9B, and 9D) are the three plots with least red spider. This may, however, be mere coincidence, for plot 8C, with 56.2 per cent. of growth, has the same figure for red spider attack as plot 9D, with only 29.2 per cent.

As all observations have been recorded for each individual bush, however, it is possible to correlate red spider attack with growth made by the plants at the end of the first rains, at the

beginning of the rains, and when planted as seed. When this is done the following results are obtained :—

Growth by mid-October.	*Percentage Insity of Red Spider Attack in February.*
Plants 10 inches and more	24.7
,, 6 to 10 inches	19.1
,, less than 6 inches	8.0

Growth by mid-April	*Percentage Insity of Red Spider Attack in February.*
Plants 4 inches and more	26.0
,, 3 to 4 inches	25.5
,, 2 to 3 inches	21.1
,, 1 to 2 inches	16.7
,, less than 1 inch	15.1

Development of seed when planted.	*Percentage Insity of Red Spider Attack in February.*
Root 1 inch or more	21.0
,, ½ to 1 inch	23.2
,, less than ½ inch	19.7
Seed cracked only	17.9
Ungerminated	17.2

Thus, red spider attack was worst on—

plants of which the seed was best developed at the time of planting.

plants which were best developed at the beginning of the season.

plants which were best developed at the end of the season.

As we turn from the plants showing vigorous growth to those showing less vigorous growth it is found that the intensity of red spider attack diminishes. This is certainly not the result that would have been expected by the majority of planters, and there is no evidence to show that these results would be obtained under different

circumstances. In this case, however, the observations show definitely that it was not the bushes which one would call " weak " that got most red spider, but rather the reverse.

Conclusion.—The above observations are not recorded as being the result of exhaustive experiments on the growth of young tea. The observations were made, more or less by the way, in connection with other work, and are recorded, for what they are worth, as being suggestive, rather than instructive, with regard to a matter on which little or no information is available.

The figures given for the percentage of plants obtained are probably lower than is normally the case, as not only were soil conditions inferior, but the seeds were sown three feet apart, so that the shading effect obtained by close planting in a nursery was lacking. On the other hand, the figures do definitely show that

1. Other things being equal, the seed which germinates quickest gives the biggest proportion of good plants.
2. Soil conditions, as evidenced by acidity, have a great effect on growth, decrease in acidity producing decreased growth.
3. Growth in the cold weather follows the same course as in the rainy season, in that the most vigorous plants make most growth, and the difference in the development of a plant at the beginning and end of the cold weather may be considerable.
4. Slow germination does not necessarily mean a poor plant. Plants which lag behind to begin with may overtake plants which are further forward at any time during the first rains or the succeeding cold weather, and this apart from the fact of their being planted in better soil.
5. In this case, vigour, as measured by growth, did not mean increased resistance to red spider, but rather the reverse.

MOISTURE CHANGES DURING THE MANUFACTURE OF BLACK TEA.

BY

C. R. HARLER.

Fresh tea leaf, as it is plucked, contains about 77 per cent. moisture and finished black tea about 6 per cent. During manufacture water is lost from the leaf at varying rates and it is instructive to consider these losses.

Moisture loss during withering.

During the withering process the leaf loses moisture and becomes flaccid. This loss is necessary if the leaf is to be suitably rolled, but it is also the main factor in bringing about the changes going on within the leaf which constitute the chemical wither.

The degree of the chemical wither is influenced by time, temperature and the amount of drying of the leaf. Each of these factors may be varied within limits. Experience has shown that withering temperatures much above 90°F. are likely to harm the tea. It has been observed that very rapid drying of the leaf does not give such good results as steady drying. It is also well known that leaf kept much above 24 hours is liable, especially in the rains, to go sour.

So far as practical experience goes in North-East India it has been noticed that, during the rains, when the average temperature is about 83°F., the best tea is made from leaf withered in a cool place till it contains about 66 per cent. moisture. The length of time of the wither is limited because the leaf goes sour after a time. On the other hand the time may not be reduced beyond a certain limit for, although the physical wither may be obtained in two or three hours, it takes much longer than this for the chemical wither to develop.

The amount of drying during withering has an important influence on the kind of tea made. Hypothetically, it is possible to produce the same chemical state in the leaf without drying as with it, but, even if this state of affairs be realised, the

subsequent course of the chemical reactions which constitute fermentation is influenced largely by the physical condition of the leaf. A turgid leaf is smashed in the roller whilst a flaccid leaf is rolled. Estimations show that the rate of change of the tannin bodies in the smashed leaf is very different from that in the rolled leaf. It is also possible that the nature of the change is different in the two cases.

All leaf does not contain the same amount of moisture as it comes from the field. Quick growing shoots contain more moisture than slow growing ones, and tea grown in the shade contains more moisture than that grown in the open. During the season, leaf plucked from a certain plot at Tocklai showed the following average moisture percentages each month. The shoots plucked consisted of regular two leaves and a bud.

May ...	Average	moisture	in	leaf ...	76.0	%
June ...	,,	,,	,,	...	77.3	,,
July ...	,,	,,	,,	...	78.7	,,
August	,,	,,	,,	...	77.0	,,
September	,,	,,	,,	...	77.5	,,
October	,,	,,	,,	...	77.9	,,
November	,,	,,	,,	...	77.5	,,

The dryest leaf was collected in May when one plucking showed a moisture content of 75.7 per cent. In July one plucking consisted of leaf containing 81.0 per cent. of moisture.

In order to obtain the correct physical wither, leaf has to be dried according to its original moisture content. The table below shows to what extent 100 lbs. of fresh leaf must be dried in order that it shall contain 66 per cent. moisture.

Moisture content of fresh leaf.				Degree of drying necessary.				
80	per cent.	...	100	lbs.	should	dry to	60	lbs.
77	,,	,,	... 100	,,	,,	,,	69	,,
75	,,	,,	... 100	,,	,,	,,	75	,,
72	,,	,,	... 100	,,	,,	,,	84	,,

Leaf rarely contains less than 75 per cent. moisture at any time and 77 per cent. may be taken as a safe average. Three

leaves and a bud contain about the same moisture percentage as a finer plucked shoot, but the coarser the leaf the longer it takes to wither physically.

Although the chemical wither must vary with each change made in the three controlling factors, temperature, time and drying, the average temperature is fairly constant during the rains and the time of withering is approximately 18 hours. With these two factors thus loosely defined the best check on the wither is kept by weighing the leaf. For this purpose, a rack in a typical part of the loft or a bay in the leaf house may be spread with leaf which is weighed before and after the withering period. In a very short time, the man in charge of the factory will thus learn what constitutes the degree of drying necessary for a good chemical wither. When this is accomplished the daily weighment of a typical rack may cease.

If the leaf is withered under control in a loft, the fans should be turned off after the necessary physical wither is obtained and a wait made for the chemical wither to develop. If the leaf must be cleared and rolled before 18 hours elapse, in order to make room for incoming leaf, then the physical wither may be carried further than denoted in the table above. Exactly how much further cannot at present be indicated, however.

In order to know exactly what degree of wither is necessary it is essential to know the moisture content of the fresh leaf. This can only be determined by the method described later. Unless such a determination is made, it should be assumed that the fresh leaf contains 75 to 77 per cent. moisture when it arrives at the factory.

Moisture loss during firing.

During rolling and fermentation no loss in moisture should occur, although in practice, some drying takes place. Often watery juice is expressed from the leaf during hard rolling, but this usually signifies an insufficient physical wither. In the fermenting room the leaf sometimes dries slightly, but this may be obviated by suitable humidification.

During the first firing, the tea should be dried to at least 12 annas, *i.e.*, till it is crisp. At this state of dryness the moisture content is about 30 per cent. Our recommendations regarding the firing of tea include an initial temperature in the firing machine of 180°F. and a temperature of 120°F. above the top tray where the cooled, moist air leaves the firing machine. More important, however, than these suggestions is a need for the tea to be discharged at least 12-annas dry. Unless this is so, it indicates that the leaf has been stewing and, rather than this shall take place, it is preferable to raise the temperature of the firing machine, in order to be able to dry the leaf to 12-annas during the first fire.

Since the practice of lowering the initial firing temperatures from 220°F. to 180°F. has become general most factories are found to be under-machined. The shortage of drying space can however be overcome by raising the speed of the dryer fan. In this connection the following calculations are of interest. A big Empire Dryer can dry 20 maunds of rolled leaf containing 66 per cent. moisture to 10 maunds 12-annas dried tea containing 30 per cent. moisture in an hour, the machine running with an initial temperature of 220°F. When the temperature is lowered to 180°F., the output of 12-annas fired tea is reduced from 10 maunds to about 7 maunds per hour. If, however, the fan speed is increased from 450 to 500 r.p.m., the air blast is increased in the ratio of almost 4 to 5. The output of 12-annas fired tea at 180°F. is similarly increased, and difficulties owing to machine shortage are largely overcome.

During the second firing the tea is dried to about 4 per cent. moisture, although during sorting this value usually rises to about 6 per cent. The moisture changes during manufacture in the rains may be tabulated as under :—

Fresh leaf	...	contains about	77	per cent.	moisture.
Withered leaf	...	,, ,,	66	,,	,,
First fired tea	...	,, ,,	30	,,	,,
Final ,, ,,	...	,, ,,	4	,,	,,
Packed tea	...	,, ,,	6	,,	,,

On these figures, 100 lbs. of leaf will produce just under 24½ lbs. of tea of all grades.

Moisture changes during sorting.

The rate and conditions under which tea picks up moisture have been studied by Deuss in Java (1). He placed different grades, both leaf and broken, into vessels in which the atmosphere was kept at different degrees of humidity. The teas were prepared so that they contained approximately 0, 2, 4, 10—12 and 14—16 per cent. moisture. The closed vessels into which the samples were placed were regulated to the following atmospheric conditions :—

(1) Over quicklime	... Relative humidity of air	... 0	%
(2) Over 70 % sulphuric acid	,, ,,	... 9	,,
(3) Over saturated solution of calcium chloride	,, ,,	... 30	,,
(4) Over 43 % sulphuric acid	,, ,,	... 50	,,
(5) Over water	,, ,,	... 100	,,

Further samples were exposed to the air of the laboratory where a self-registering hygrometer showed the humidity to vary between 70 and 80 per cent.

The gain or loss in weight of the samples was determined daily, and the results were found to be the same for all grades of tea. Over quicklime all the teas lost moisture, tending to a minimum of ½ per cent., irrespective of the original moisture content of the sample. The loss was greatest during the first two days.

With a relative humidity of 9 per cent. (over 70 per cent. sulphuric acid) the loss of water was less pronounced. In atmospheres of 30 per cent. and 50 per cent. humidity, all the teas, even those which contained only 4.7 per cent. moisture, still lost water.

The teas kept in a saturated atmosphere (humidity 100 per cent.) all absorbed moisture, even those which originally con-

(1) Deuss J. J. B.—Over het water aantrekkend vermogen van thee—*De Thee*, Sept. 1926, pp. 97-101.

tained 14-16 per cent. Within six days the moisture content had risen to 26.5 per cent. in some cases.

In the atmosphere of the laboratory (humidity 70-80 per cent.) Deuss found that teas which contained 14.8 to 15.8 per cent. moisture, lost water. Those containing 1 to 9.9 per cent. moisture, absorbed water from the air. When the humidity of the atmosphere fell to 55-60 per cent., all the teas began to lose moisture again only to reabsorb it when the humidity of the air rose to 70-80 per cent.

It may be concluded from the above, that ordinary tea, which has a moisture content of about 4 to 8 per cent., will keep its moisture value fairly constant in an atmosphere of relative humidity 60-65 per cent., so that the latter should be the relative humidity of the sifting room.

Deuss suggests that the humidity of the sifting room be controlled by drawing in warm air from the drying room.

In North-East India it is common to *gap* or *pukka bhatti* the tea before boxing by passing it quickly through a dryer at about 150°F. This we consider to be necessary if the tea contains more than 6 per cent. moisture, but, in the majority of cases where moisture estimations have been made, it has been shown that final firing is not necessary. If leaf is dried to about 6 per cent. and sorted in a room where the relative humidity is 60-65 per cent., no appreciable extra moisture will be gained or lost during sorting. Wet and dry bulb thermometers should be placed in the sorting room and a check kept on the humidity. If the dry bulb is 85°F. then the wet bulb should read about 76°F., to indicate a relative humidity of 65 per cent. With dry bulb readings of 90°F., 95°F., and 100°F., the wet bulb should read 10°F. lower.

Although tea, during sorting, is liable to rapid changes in moisture content, tea stacked in heaps does not change much in a short time. Observations made in the Dooars have shown that the moisture content of the outer portion of the heap, a layer of

an inch or so, changes rapidly, but that, inside the heap, the change is negligible during the first day or two of stacking.

In North-East India it is usual to aim at 6 per cent. moisture in packed tea and to this end it is becoming common for tea factories to instal apparatus for accurately determining moisture. Observations carried on throughout the season at New Glencoe Estate in the Dooars (2) showed that in the early part of the season when " breaks " were made at long intervals, the tea often picked up so much moisture that a final fire was necessary before packing. In the rains, however, when tea was bulked and packed soon after it was made, the moisture content seldom touched 6 per cent. and final firing was unnecessary. In other factories the great value of moisture estimations has also been demonstrated.

Estimation of moisture.

Although many planters, with years of experience to draw upon, can decide, with some accuracy, whether a tea should be final fired or not, it is much more reliable, and certainly worth while, to estimate scientifically the moisture in tea before packing. Such an estimation may not only save an uneconomic final fire but also, by showing that a final fire is unnecessary, lead to an improvement in the tea which, if packed too dry, will not mellow or mature.

The apparatus required for moisture determinations is as follows :—

1. One chemical balance in case accurate to 0.005 gms.
2. One box of weights—50 gms. to 0.01 gms.
3. One copper steam oven, 23 cms.
4. One desiccator with porcelain plate, diameter 15 cms.
5. One dozen porcelain basin 6 cms. diameter.
6. Five pounds calcium chloride for desiccator.
7. One Primus Stove.

(2) We are indebted to Mr. Haines of New Glencoe Estate for very full moisture estimations made during the 1927 season.

The cost of this apparatus, which may be purchased in Calcutta, is under Rs. 200.

The moisture content of leaf or of tea is estimated by completely drying a weighed quantity of the substance in an oven heated to 100°C. by boiling water. The dried sample is then weighed and the loss, which constitutes the water driven off, is calculated. Detailed steps of the estimation are as follows :—

1. Accurately weigh a clean porcelain basin to the nearest 0.01 gm.
2. Take a fair average sample of tea and weigh accurately into the basin 10 gms. of same.
3. Place basin and tea in steam oven in which water is kept boiling by a Primus stove or other suitable means. Keep in oven for two hours.
4. Take basin and tea from oven and put in desiccator to cool over calcium chloride.
5. Weigh cooled basin and tea quickly.

If this operation is not carried out in a few minutes the tea, being hygroscopic, will pick up moisture and increase in weight.

6. Put basin and tea back into steam oven for an hour. Cool and weigh again.

If second weight differs by more than 0.2 gms. from the first, put basin back into oven for an hour, cool and weigh again.

The calculations are made as follows. For example :—

Weight of basin	24.23 gms.
,, ,, + tea	34.23 ,,
Weight of tea ...	10.00 ,,
,, ,, ,, after heating (1) ...	33.88 ,,
,, ,, ,, ,, ,, (2) ...	33.87 ,,
Weight of dried tea	9.44 gms.
Loss in weight	0.56 ,,
Moisture	5.6 per cent.

The desiccator is a glass vessel with a glass lid, rendered close fitting by a little grease. In the bottom of the vessel is a space for calcium chloride, which keeps the air within the dessiccator dry. The basin and tea must be cooled before they are weighed, otherwise accurate weighment is impossible.

The apparatus is not only of use in determining the moisture of finished tea but also in checking the moisture percentage of the first fired tea and of the fresh leaf.

In Java it is becoming the practice in tea factories to estimate the moisure in tea before it is packed. In that country a somewhat different method of estimation is employed. Twenty-five grams of tea are placed in a copper flask with toluene, and the mixture boiled. The vapours, consisting of steam from the moisture in the tea and toluene, are condensed and returned to a graduated tube, in which the water sinks as a layer below the toluene. The volume of water is easily read off in the tube and the moisture percentage in the tea calculated.

COLD WEATHER SPRAYING.

BY

A. C. TUNSTALL.

It has now been generally accepted as a result of experience that spraying with lime sulphur solution is a valuable addition to the general routine of tea culture in North-East India. Unfortunately it is rarely possible to spray the whole area of a garden without undue interference with other equally important work. It is therefore necessary for the managers concerned to select which blocks they will spray. The object of this article is to help planters to make this selection.

First of all there are some diseases which, if not treated directly by the application of fungicides, will cause serious losses. It will always pay to spray tea which is attacked by such diseases even when the attack is slight. There is no difficulty in making a decision in such cases. It is where there is no disease of this nature that it is sometimes hard to decide which section should be selected for spraying.

It is necessary to have a clear idea of the work which spraying with a fungicide such as lime sulphur solution is intended to do. The lime sulphur solution will kill the fungi with which it comes into contact. It has no power to kill fungi which are in such a position that the fungicide cannot reach them. A fungicidal spray fluid therefore has no direct effect on fungi already present inside the tissues of the plant but it may of course be helpful in preventing these fungi getting into the tissues by killing these before they enter. In this manner it tends to reduce the amount of disease attacking the woody portions of the plant by protecting the wounds. Once a fungus is within the woody tissues of the plant the application of a fungicide has no direct influence upon it. It is therefore useless to spray a tea bush with rotten branches with the object of killing the fungus producing the rot.

There are however many fungi which cause considerable damage to the plant without penetrating so deeply that a fungicide applied externally will have no influence upon them. Examples of this type of fungus are those causing Thread blight and Black rot. While the fungi which cause Brown blight, Grey blight, Blister blight only remain immersed in the tissues for a comparatively short time. The application of lime sulphur solution by reducing these fungi improves the health of the bushes and so indirectly helps to reduce loss due to other fungi. The diseases which are most readily influenced by spraying are those which attack the younger portions of the plant, particularly the green portions. If all the younger portions are cut off as in heavy pruning the possible benefit likely to accrue from spraying is very limited. If applied immediately after pruning it is more or less confined to the temporary protection afforded to the wounds. It is therefore unlikely that any spectacular increases in crop will result from spraying heavy pruned tea. Unless such tea is badly hidebound or it is known to have been infected by a dangerous disease such as Black rot before pruning it may be left out of the spraying programme. The same applies to stick pruned tea.

The best results from spraying may be expected from tea which bears the maximum amount of young growth, *i.e.*, top pruned or unpruned tea. Unfortunately such tea is much more difficult to spray and the fluid required per acre is often more than double that required for stick pruned and heavy pruned. On this account many planters only spray the heavy pruned and stick pruned areas. This is a mistake although the cost of spraying such areas is less the increase in crop as a result of the spraying is also less and the profit per unit of money invested is not so great.

On most gardens more than half the area is top pruned or unpruned annually and it frequently happens that it is impossible to spray the whole of this area. It is therefore necessary to make a further selection. If a disease known to be likely to cause serious loss is present on any of the sections concerned it is of

course obvious that those sections should be chosen for spraying and it would be better to arrange to spray those sections twice rather than a larger area once.

Where no special disease is present it is well to select the areas expected to give the highest yield. Experience has shown that the greatest increase is likely to be obtained from the highest yielding areas while the cost of application is approximately the same. After all the object of all operations on a tea garden should be to obtain profit. The reduction in the amount of disease present on a particular area is only undertaken with a view to increasing profit. In the case of the commoner diseases such as Brown blight, Grey blight, Red rust total eradication is quite out of the question and unless the cost of special operations for their reduction is likely to be balanced by the value of the increased crop it would be more profitable to confine one's attention to other methods of increasing crop such as manuring, resting, etc.

To make this point clear let us consider two sections neither of which are attacked by a particularly dangerous disease but both attacked by the usual mixture of Brown blight, Grey blight and Red rust. In the one section the bushes have poor frames, say 10 per cent. of vacancies, and only yielding a total of five maunds of tea per acre. Assuming that the reduction in blight brought about by spraying will yield 10 per cent. more leaf (this is a reasonable figure) this only means half a maund of tea per acre. This increased profit may in some cases barely cover the cost of spraying. It would probably pay better in those cases to spend the same amount of money and labour on increased manuring, filling in vacancies and increasing the vigour of the bushes by leaving the poorer ones unplucked. In the case of a section yielding ten maunds per acre however an increase of 10 per cent. due to reduction in blight would always pay a handsome profit on the cost of spraying. It is therefore suggested that in the absence of disease likely to assume epidemic form under conditions favourable to the parasite concerned spraying should be

limited to areas on which an increase of 10 per cent. in the crop will pay good profit on the cost of the operation.

On most gardens it is difficult to find the necessary labour for spraying on a large scale except during the period between the completion of the pruning and the commencement of the plucking. This is fortunately the best season for the application of fungicides to top pruned and unpruned tea. It is however unsuitable for the treatment of heavy pruned and stick pruned bushes as the presence of the tender shoots renders it necessary to reduce the strength of the solution applied. Where it is desirable to spray such tea the spraying should be carried out immediately after the pruning of the sections concerned. Where a disease such as Black rot has been present on the tea before it was pruned a second application should be made after the removal of the first flush. This should also be made in the case of unpruned and top pruned sections where diseases of this nature have been present in the previous season. Where no serious disease has been found it usually pays better to spray a larger area once than a smaller area twice.

In all cases, however, it is of the utmost importance to see that the work is properly done. The manager himself or a responsible assistant should ascertain by experiment the amount of fluid necessary to cover every part of a number of bushes representative of each type of pruning completely and thus estimate the amount of fluid required per acre in each case. If this item is known it is comparatively simple to check the work. The success of the spraying depends first on the preparation of the fluid and secondly on the completeness of the covering of the bushes with a film of the fluid. For purposes of estimating the amount of fluid required per acre the figures given in "Quarterly Journal," Part IV, 1926, may be taken but those figures are only useful for that purpose. The actual amount required must be ascertained by experiment on the sections concerned.

The preparation of the concentrated fluid needs care. The principal difficulty is the lime. Unless good quicklime can be

obtained it is better to buy the solution ready made from Calcutta chemical firms. A solution of 30° Beaume concentration may be obtained at Rs. 2 per gallon. If good quicklime can be obtained it is certainly much cheaper to make the solution on the garden, but it is necessary to supervise the manufacture carefully. Details of the manufacture and the dilution necessary for both home made and ready made concentrated solutions may be found in " Quarterly Journal," Part IV, 1926.

The question is often asked whether it is possible to make a more concentrated solution on the garden. It is quite possible but on account of the additional supervision required it is not practical. When preparing very concentrated solutions extreme care is necessary both in the purity of the materials and in the methods employed. For instance, the temperature and time of boiling require to be exact—too short or too prolonged boiling will give a different concentration. The easiest way to prepare the concentrated fluid is by injecting steam from a boiler. It is however necessary to use a thermometer to ascertain when the liquid is actually boiling as it is impossible to say whether the fluid is actually boiling when steam is bubbling through it.

To ensure even distribution of the fluid it is essential to have the machines in good condition. It is particularly important to see that the nozzles produce a film mist-like spray. Too often the apertures have become worn and the spray is too coarse. It is a good plan to replace the nozzle apertures every year. The hole should not be much larger than that made by a large size darning needle and the spray produced should be fine enough to float on the wind. Within limits the finer the spray produced the more efficient the spraying. It is obvious that more fluid will be used to cover the bush if the drops are large. The object in view is to obtain an unbroken film of fluid over all parts of the plant. Nothing is gained by putting on more than this as it will merely run off into the ground.

To do spraying economically it is necessary to think out the organisation carefully. Unless this is done a great amount of

time and money may be lost. For this reason it is desirable to restrict the spraying to a comparatively small area in the first season and in future years utilise the experience gained when a large area may be undertaken. It is foolish to attempt to spray the whole area of a large garden in the first season unless the presence of a serious disease makes it imperative.

While it is safe to assume that not less than 10 per cent. of the total crop in North-East India lost annually from the combined effects of the diseases caused by the commoner vegetable parasites could be saved by spraying it does not follow that it would pay to spray the whole area as in some cases the cost of the application would exceed the value of the tea saved.

To summarise—

1. Spraying with a fungicide will only directly influence vegetable parasites with which it may come into intimate contact.
2. It is useless against parasites which are at the time of application immersed in the tissues of the plant.
3. Under ordinary conditions most of the diseases likely to be influenced by spraying are removed when a bush is heavy pruned or stick pruned. The benefit likely to accrue from spraying is therefore limited to the temporary protection of wounds, the softening of hide-bound bark and the removal of such parasitic fungi, *e.g.*, Thread blight, Black rot fungus, which may be present outside the old bark.
4. Spraying is likely to be most beneficial to top pruned or unpruned tea.
5. The highest yielding sections are likely to give greater increases as the result of spraying than poorer yielding ones.
6. Where certain diseases likely to cause serious damage are known to be present it is desirable to spray the sections concerned under any circumstances.

7. Good quicklime is essential for the preparation of good lime-sulphur solution.

8. The solution must be boiled properly.

9. A fine spray is essential to efficient spraying and attention should be paid to the size of the apertures in the nozzles.

10. To obtain good results from spraying it is necessary to organise the work carefully.

A great deal can be learned about a section of tea by studying the yields for each round of plucking for the previous season.

If we plot the yields for each plucking of a light pruned or unpruned section on squared paper it is possible to identify the different flushes by the shape of the curve. By adding together the yields constituting each flush we obtain five or six numbers. If we divide these numbers by the area in acres of the section concerned we have the yield per acre for each flush. This can be done with the yields for each plucking for all the sections on the garden. If these figures are plotted on squared paper it is possible to compare sections which have been similarly treated. The difference between the curves of sections attacked by disease can often be seen at a glance and it is frequently possible to obtain some idea of the losses caused by particular diseases. If managers care to send the necessary information to Tocklai the writer is willing to work out the figures and make suggestions thereon. The following information is necessary :—

1. The yield for each round of plucking of

(*a*) the doubtful section.

(*b*) a similarly pruned section apparently healthy and vigorous.

2. The pruning and annual yields of each of the sections concerned for the previous five years.